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Circularly Polarized Microstrip Patch Antenna

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Abstract: In this study, a new compact Circularly Polarized (CP) antenna is presented. The impedance matching and the radiation characteristics of this proposed structure is studied using method of moment techniques. The proposed antenna is based on L-probe fed with thick air-filled substrate, truncated corners and two L-shaped slits on the patch. The achievable bandwidth of the proposed antenna obtained is 27% (2.14-2.81 GHz) at -10 dB return loss. The radiation pattern of the antenna shows that the antenna radiates in Right Hand Circular Polarization (RHCP) with achieving an Axial Ratio (AR) bandwidth of 4.3% at 3 dB and a maximum gain of 8.7 dBi. The proposed antenna is suitable for the application in Wireless Local Area Network (WLAN) 2.4 GHz frequency band. The details of the proposed design method is presented and discussed.

Key words: Circularly polarized antenna, L-probe feed, WLAN antenna

INTRODUCTION

The booming demand for a variety of new wireless application for wireless system such as WLAN, it is important to design broadband antennas to cover a wide frequency range. Microstrip patch antennas have found extensive application in wireless communication system owing to their advantages such as low-profile, conformability, low-cost fabrication and ease of integration with feed-networks (He *et al*., 2008). However, the impedance and axial bandwidth of conventional patch antennas are too narrow to be widely used in the real environments. Recently, a great interest in Circularly Polarized (CP) antennas has been found for enhancing impedance and axial bandwidth. Circularly polarization is one of the common polarization schemes used current wireless communication systems due to flexibility in orientation angle between transmitter and receiver, better mobility and weather penetration and reduction in multipath reflections. The CP waves are produced when two orthogonal linearly polarized modes, of equal amplitude and 90° phase difference, are excited.

Several techniques have been realized reducing the size of the antenna with a modest bandwidth for circular polarization operation (Ramirez *et al*., 2000; Wong and Chiou, 2000; Chen *et al*., 2001). In (Iwasaki, 1996), a circularly polarized circular microstrip antenna with the centrally located cross-slot in the patch conductor is introduced. The cross-rectangular slot provides necessary perturbation to excite dual orthogonal modes to generate the circular polarization. However, the 3 dB axial ratio (AR) bandwidth of this antenna is only 0.65 %. Recently, two other antennas reported in Nasimuddin and Verma (2005a) and Lien *et al*. (2007) offer 3 dB AR bandwidths of 14 and 23%, respectively. However, these consist of stacked (multiple metal/dielectric) configurations and hence are considered difficult to fabricate reliably. On the other hand, a simple probe feed H-shaped microstrip antenna fed along its diagonal to excite the CP operation is investigated (Liu and Kao, 2007). But the AR bandwidth reported is only about 1.3%. More recently, a circular dumbbell cross-slot circularly polarized antenna has developed which can achieve an optimum 3 dB AR bandwidth of 2.22% and impedance bandwidth of 9.13% at -10 dB return loss (Nasimuddin and Verma, 2005b). Another circularly polarized antenna by splitting the fundamental mode has investigated with impedance bandwidth of 5.7% and axial ratio bandwidth of 1.3% (Malekabadi *et al*., 2008). In this study, a new single feed circularly polarized antenna for 2.4 GHz wireless local-area network (WLAN: 2.4-2.4835 GHz) application is presented. The antenna consists of L-probe fed with two L-shaped slits on the patch for enhancing bandwidth, axial ratio and the gain. A good impedance bandwidth of 27% and 3 dB axial ratio bandwidth of 4.3% is achieved with maintaining a maximum gain of 8.7 dBi.

ANTENNA DESIGN

Figure 1a and b shows the geometry and parameters of the proposed circularly polarized antenna. The

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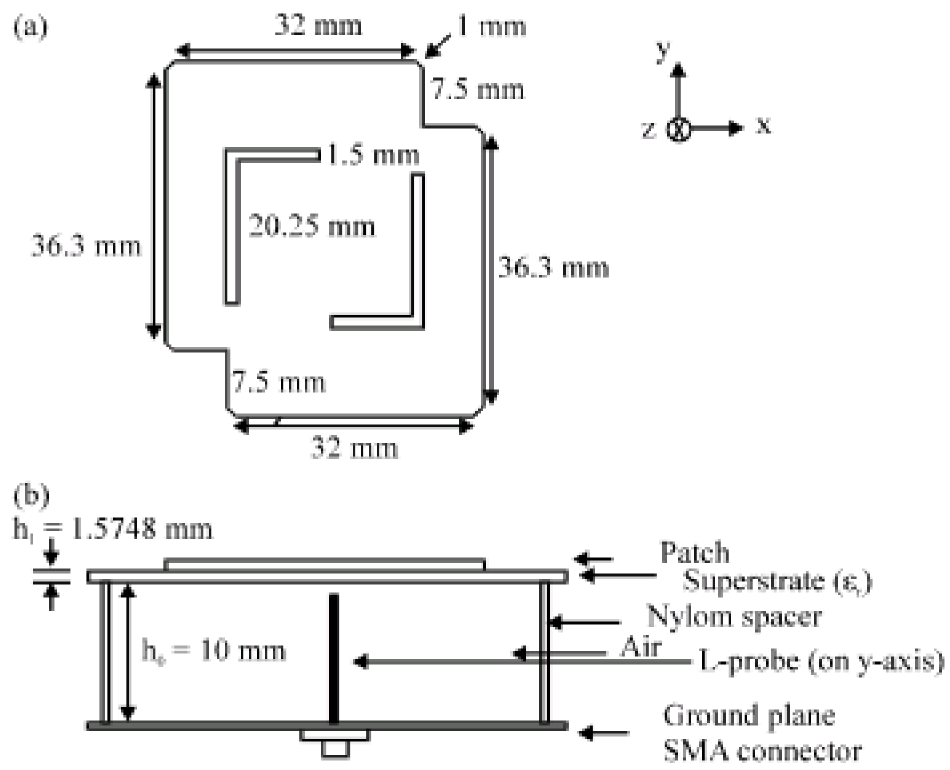

Fig. 1: Geometry of the proposed patch antenna. (a) Top view and (b) side view

structure incorporates an antenna element, air-filled substrate (layer), L-probe feed technique and two L-shaped slits. The dimension of the patch is 46.8×42.5 mm. The patch is supported by a superstrate with dielectric constant ε_r (2.2) and thickness h_1 (1.5748 mm). The patch is fed by L probe along the centerline (y-axis) of the patch. An air-filled substrate with thickness h_o (10 mm) is sandwiched between the superstrate and a ground plane. An Aluminum plate with dimensions of 200×180 mm and thickness of 1 mm is used as the ground plane. The use of probe feeding technique, two L-shaped slits on the patch with thick air-filled substrate provide bandwidth and gain enhancement. The CP is obtained in the design by choosing truncated corner on the radiating patch to excite with a 90° phase shift. Truncated corner of patch antenna with embedded two L-shaped slits is designed to operate at 2.4 GHz band. The right hand circular polarization or Left Hand Circular Polarization (LHCP) depends on choosing the feeding position. In this design, Right Hand Circular Polarization (RHCP) is chosen by feeding the RF power in y-axis. By adjusting the L-shaped slits on the patch with proper feeding of L-probe, the proposed antenna achieves an important bandwidth broadening.

RESULTS AND DISCUSSION

The resonant properties of the proposed antenna have been optimized by using commercially available EM simulator software named IE3D v12. Figure 2 shows the simulated result of the return loss of the proposed antenna. The simulated impedance bandwidth of 27% (2.14 to 2.81 GHz) is achieved at -10 dB return loss (VSWR≤2). Due to the electromagnetic coupling in

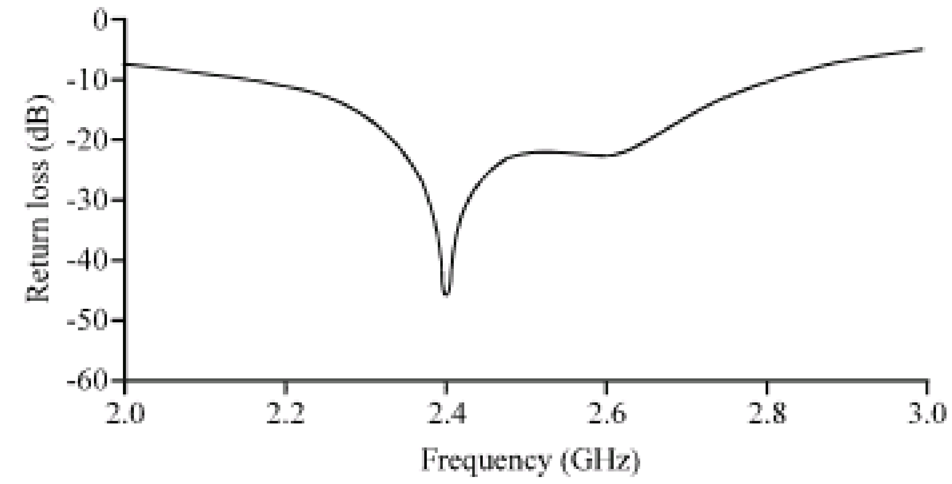

Fig. 2: Simulated return loss of the proposed patch antenna

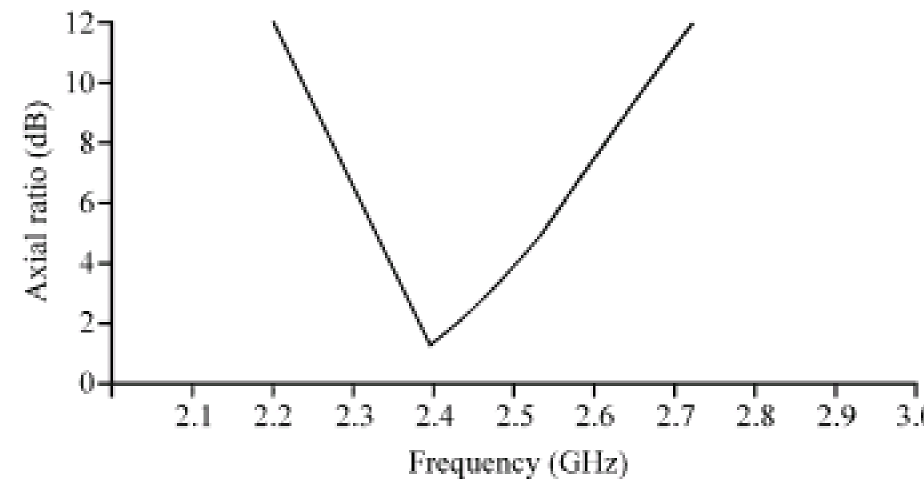

Fig. 3: Simulated axial ratio of the proposed patch antenna

between L-probe, radiating patch and ground plane, such a wideband impedance bandwidth is achieved. The resonant frequency at 2.4 GHz exhibits a better return loss of -46 dB. The axial ratio of the proposed antenna is shown in Fig. 3. A 3dB achievable axial ratio bandwidth of 4.3% (100 MHz) is achieved with the use of rectangular truncated corners which alters the current flowing around the slots on the patch.

The simulated radiation patterns at the frequency of 2.4 GHz in the *xz*-plane and *yz*-plane are plotted in Fig. 4. As shown in Fig. 4a and b, the designed antenna display good radiation patterns in the *xz*-plane and *yz*-plane at the frequency of 2.4 GHz for Right Hand Circular Polarization (RHCP) and Left Hand Circular Polarization (LHCP). In the figure, the RHCP plot is greater than LHCP at the broadside direction. Hence, this antenna is radiating in right hand circular polarization for both plane.

Figure 5 depicts the simulated gain of the proposed patch antenna. As shown in the figure, the maximum gain of 8.7 dBi is achieved at the frequency of 2.5 GHz. The thick air layer leads gain enhancement in this design.

Figure 6 shows the current distribution on the patch at 2.4 GHz Arrows shows the direction of the current. It can be seen that the current intensively flows mainly on the truncated corners and cutting edge of L-shaped slits.

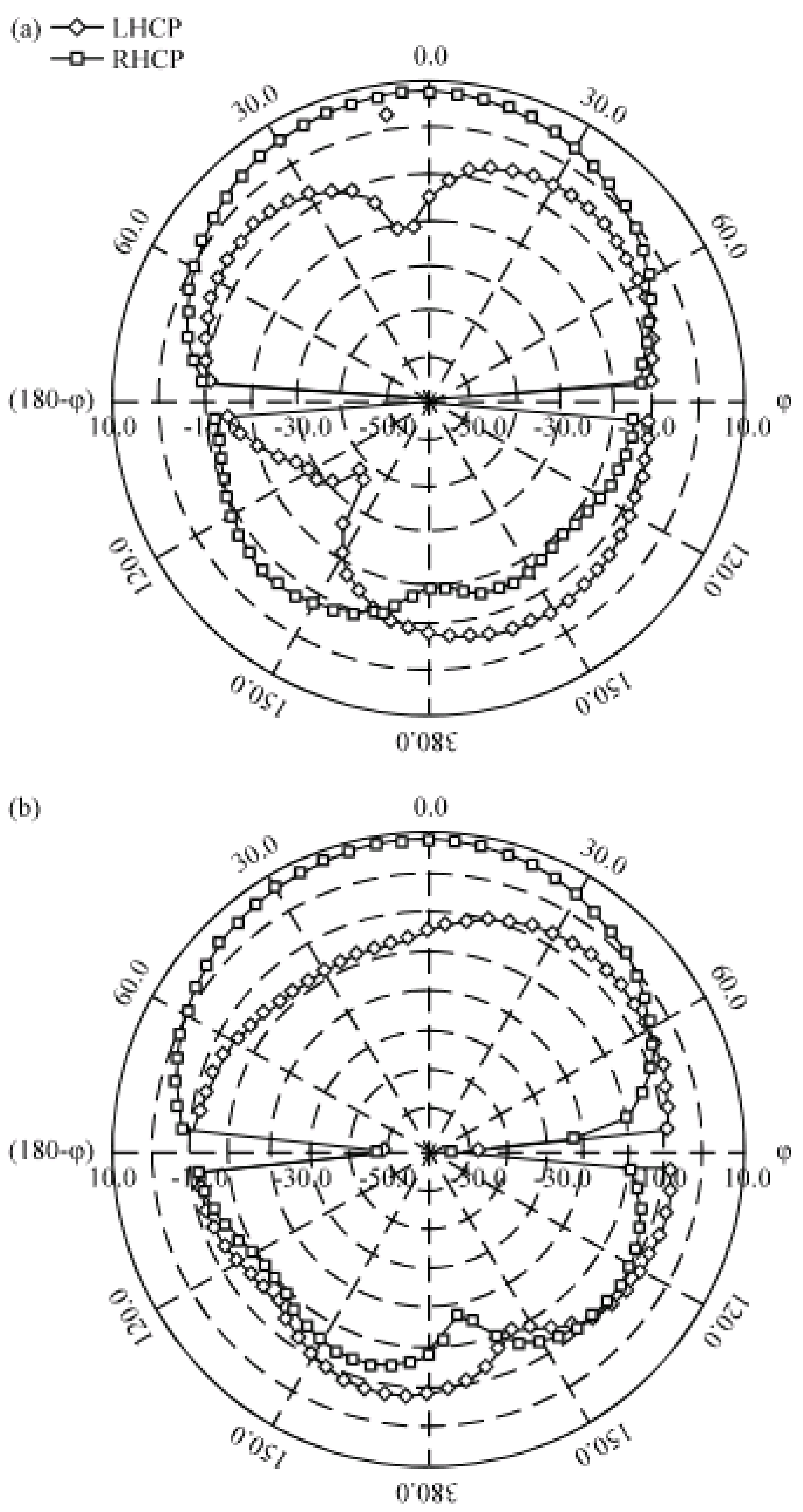

Fig. 4: Radiation pattern of proposed patch antenna at 2.4 GHz for (a) xz-plane and (b) yz-plane

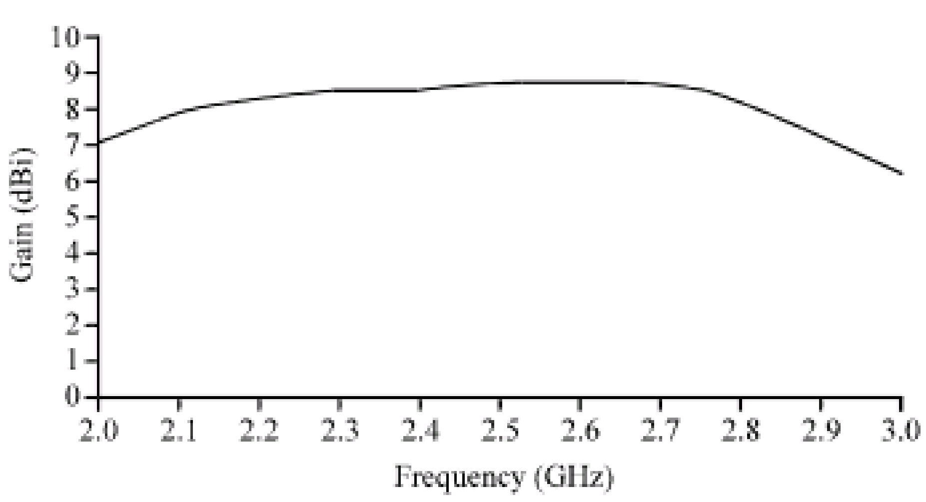

Fig. 5: Simulated gain of proposed patch antennas at different frequencies

The proposed antenna is designed to operate at WLAN 2.4 GHz frequency band. By using truncated

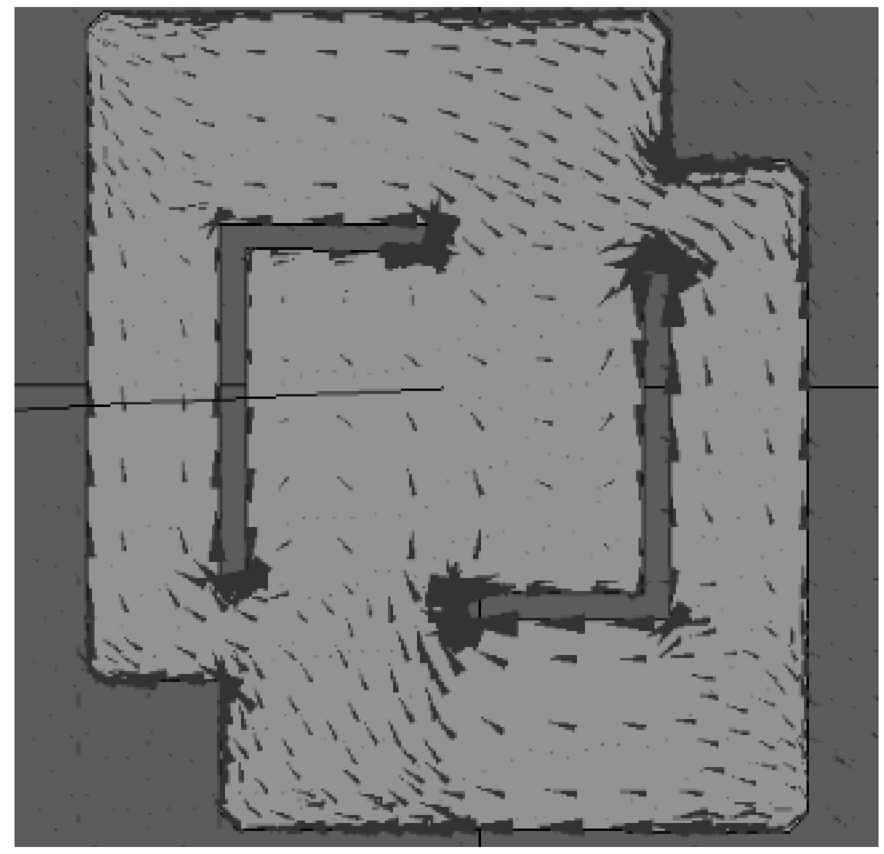

Fig. 6: Simulated current distribution on the patch at 2.4 GHz

corner on the patch antenna and two L-shaped slits, a 2.4 GHz band antenna with good radiation pattern is achieved. It can be observe that the achievable impedance bandwidth of 670 MHz and 3 dB axial ratio of 100 MHz is obtained at 2.4 GHz band which is suitable for most wireless applications. A high gain of 8.7 dBi with wider bandwidth is investigated in this design which is better then those conventional single element antennas as compared with Ramirez *et al*. (2000), Wong and Chiou (2000), Chen *et al*. (2001), Liu and Kao (2007) and Malekabadi *et al*. (2008). This is due to proper matching and introducing slits on the design and using thick air layer in between patch and ground plane. Also, most of the conventional antennas use dual feeding techniques while this proposed antenna uses single L-probe feeding technique to achieve circularly polarized antenna.

In this design, rectangular truncated corner is used to excited two orthogonal modes with 90° phase difference. The dimension of this rectangular truncated corner dominates the axial ratio of this antenna. In order to enhance the impedance bandwidth and gain, L-probe and two L-shaped slits are introduced. The feed positions of the probe determine the impedance matching and produces right hand circular polarized antenna.

From the current distribution display, it is observed that at frequency 2.4 GH, the concentrate current is on rectangular truncated corners. It can also be noticed that dominate current flow on the edge of both L-shaped slits produces lowest resonant frequency of -46 dB at 2.4 GHz. It concludes that with the aid of two L-shaped slits, the flow of the current distribute more on excited radiating element, leads wider impedance bandwidth.

CONCLUSION

In this study, a new circularly polarized antenna covering the 2.4 GHz WLAN band has been demonstrated. With incorporating L-probe fed, two L-shaped slits and truncated corners on the patch, the proposed antenna exhibits a bandwidth of 27% (2.14 to 2.81 GHz) at -10 dB return loss and a 3dB axial ratio bandwidth of 4.3% (100 MHz). The maximum achievable gain of the antenna is 8.7 dBi. In addition, the proposed antenna shows well defined RHCP radiation pattern over the band which makes the design suitable for wireless communication applications.

REFERENCES

Chen, W.S., C.K. Wu and K.L. Wang, 2001. Novel compact circularly polarized square microstrip antenna. IEEE Trans. Antennas Propag., 49: 340-342.

He, W., R. Jin and J. Geng, 2008. E-Shape patch with wideb and circular polarization for millimeter-wave communication. IEEE Trans. Antennas Propag., 56: 893-895.

Iwasaki, H., 1996. A circularly polarized small size microstrip antennas with cross slot. IEEE Trans. Antenna Propag., 44: 1399-1401.

Lien, H.C., Y.C. Lee and H.C. Tsai, 2007. Couple-fed circular polarization bow tie microstrip antenna. PIERS Online, 3: 220-224.

Liu, W.C. and P.C. Kao, 2007. Design of a probe fed H shaped microstrip antenna for circular polarization. J. Electromag. Waves Appl., 21: 857-864.

Malekabadi, S.A., M.H. Neshati and J. Rashed-Mohassel, 2008. Circular polarized dielectric resonator antennas using a single probe feed. Prog.Electromag. Res. C, 3: 81-94.

Nasimuddin, E.K. and A.K. Verma, 2005a. High Gain Compact Circularly Polarized Microstrip Antenna. IEEE TENCON., Melbourne, pp: 1-4.

Nasimuddin, K.P.E. and A.K. Verma, 2005b. A low-profile compact microwave antenna with high gain. In proc. of Applied Electromagnetics and Communications (ICECom 2005), 1-3.

Ramirez, R.R., F.D. Flaviis and N.G. Alexopoulos, 2000. Single-feed circularly polarized microstrip ring antenna and arrays. IEEE Trans. Antenna Propag, 48: 1040-1047.

Wong, K.L. and T.W. Chiou, 2000. Single patch broadband circularly polarized microstrip antennas. IEEE Int. Symp. Antenna Propag. Soc., 2: 984-987.